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ABSTRACT

Discussed are data concerning a simple visuomotor tracking task, especially the expectations and cognitive representations involved in performing such a task. The task consisted in tracking the horizontal displacement of a target spot on the screen by appropriate forearm rotations. Each subject participated in two sessions: first, at a .8 Hz target frequency and, at least 48 hours later, at a .2 Hz target frequency. In all cases, the performances were recorded during 35 full cycles of target movement. Subjects were 50 children 5 through 9 years of age. Results indicated the existence of a 90 degree phase lag at .8 Hz for the younger groups which, with increasing age, approaches monotonically the adult performance. Two control experiments, exploring the role of the velocity of the stimulus on performance, further investigated the basic characteristics of performance at the age of 6. It is concluded that the tracking of sinewaves by children depends dramatically on target frequency. The acquisition of this skill cannot be adequately described as a monotonic maturational process. One major modification appears at the age of 6 years in the strategy of perceptuo-motor coordination. This modification is relative to the control of the velocity of the movement only in case of spatio-temporal constraints. Two tables and five figures are appended. (RH)

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A DEVELOPMENTAL AND COGNITIVIST APPROACH TO A PERCEPTUO-MOTOR TASK

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INTRODUCTION

This poster presents some data about a simple visuomotor tracking task. The main emphasis of this study is on the expectations and cognitive representations involved in performing such a task. Consequently, we have only considered predictable sinusoidal target for which, unlike pseudo-random targets, an abstract representation of a general motor plan may be utilized.

We have tested this skill in children from 5 to 9 at two frequencies (.2 and .8 Hz) definitely lower and higher than the critical value (.5 Hz) above which a pure positional servomechanism does not longer allow to succeed in the task (cf. Magdaleno, Jex and Johnson, 1970).

METHOD

Subjects : 5 groups (5, 6, 7, 8, and 9 years-old boys) of 10 Ss.

Apparatus : See Fig. 1 and 2.

Task and procedure : The task consisted in tracking the horizontal displacement of a target spot on the screen by appropriate forearm rotations. Each subject participated in two sessions : first, at a .8 Hz target frequency, and at least 48 hours later, at a .2 Hz one.

In all cases, the performances were recorded during 35 full cycles of target movement (i.e. 43.75 and 175 sec respect.).

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RESULTS

Some of the younger children were unable to accomplish the required performance, especially at the higher frequency. By convention, a performance was defined correct if and only if each stimulus cycle resulted into a response cycle. However, the response may have a wrong amplitude or a phase difference with respect to the target, or present distorsions (see Fig. 2). According to this criterion, the number of subjects who performed successfully is reported in Table I.

The performances can be characterized by plotting the phase lag and the gain of the response fundamental versus the average group age (Fig. 3). At .2 Hz, the dynamics of system for those subjects who can perform the task is independent of age. At .8 Hz, a 90° phase lag exists for the younger groups which, with increasing age, approaches monotonically the adult performance.

THE CORREPONDING EVOLUTION OF THE GAIN IS NOT MONOTONE. IN PARTICULAR, THE 6 YEARS-OLD CHILDREN PRODUCE MOVEMENTS WHICH ARE MUCH SMALLER THAN THOSE OF ALL OTHER AGE GROUPS.

In order to understand the basic characteritics of the performances at the age of 6, we have undertaken two control experiments.

In the first one, we have investigated the role of the velocity of the stimulus by varying its amplitude. Results can be seen in Table II.

From this table, it appears obviously that reducing the amplitude of the target motion - thus its velocity - increases the success rate.

At this point, it becomes possible to argue that above a given threshold in velocity, the control of this parameter is deficient at the age of 6.

The second control experiment has shown that the previous conclusion can be applied only in situations where spatio-temporal constraints are imposed.

Subjects were asked to produce to and fro forearm movements in response to an auditory sinusoidal induction.
The figure 4 presents the frequency histogram of the responses compared with the auditive induction, at the age of 6.
The movements produced at the frequency of .8 Hz are characterized by a mean amplitude of 45.6 cm (sigma = 18), corresponding to a mean velocity of about 73 cm/s. Note that in the main tracking experiment, the target velocity is 48 cm/s.

DISCUSSION

The results have demonstrated the following points :

- The tracking of sinewaves by children depends dramatically on target frequency.
- The acquisition of this skill cannot be adequately described as a monotonic maturational process.
- One major modification appears at the age of 6 in the strategy of perceptuo-motor coordination.
- This modification is not relative to the control of the velocity of the movement.
- This modification is relative to the control of the velocity of the movement only in case of spatio-temporal constraints.

Considering the actual performances of the 6 years-old children (examples are shown in Figure 5), it can be suggested that the sharp reduction in gain is the consequence of the processing load associated with the control of the frequency of the stimulus.

This age consists in a transition stage between a purely reactive mode of motor control - allowing to track a low frequently stimulus - and an anticipatory mode necessary to track a high frequency one.

This last mode must be based on a central representation of the temporal characteristics of the stimulus. One can consider that this representation is elaborated during this transition stage, to the prejudice of its spatial characteristics.

REFERENCES

MAGDALENO, R.E., JEX, H.R., & JOHNSON, W.A. Tracking quasi-predictable displays : Subjective predictability, pilot model for periodic and narrow band input. Proceedings of the 5th Annual NASA-University Conference on Manual Control, 1970, 391-422.

MOUNOUD, P., VIVIANI, P., HAUERT, C.A., & GUYON, J. Visuo-manual tracking in the 5 to 9 years-old children and the adult. (submitted)

AGES :	5	6	7	8	9
.2 HZ	7	10	10	10	10
.8 HZ	3	6	8	8	10

TABLE I : NUMBER OF SUBJECTS (N = 10) WHO SUCCESSFULLY TRACK IN FUNCTION OF AGE AND TARGET FREQUENCY

AMPLITUDE (CM)	MEAN VELOCITY (CM/S)	% OF SUCCESSFULL TRIALS
< 30	< 48	80
30	48	40
> 30	> 48	20

TABLE_II : TRACKING OF A .8 HZ TARGET AT THE AGE OF 6 FOR VARYING AMPLITUDES OF THE TARGET : PERCENTAGE OF SUCCESSFUL TRIALS (N OF SUBJECTS = 5; N OF TRIALS BY SUBJECT = 6).

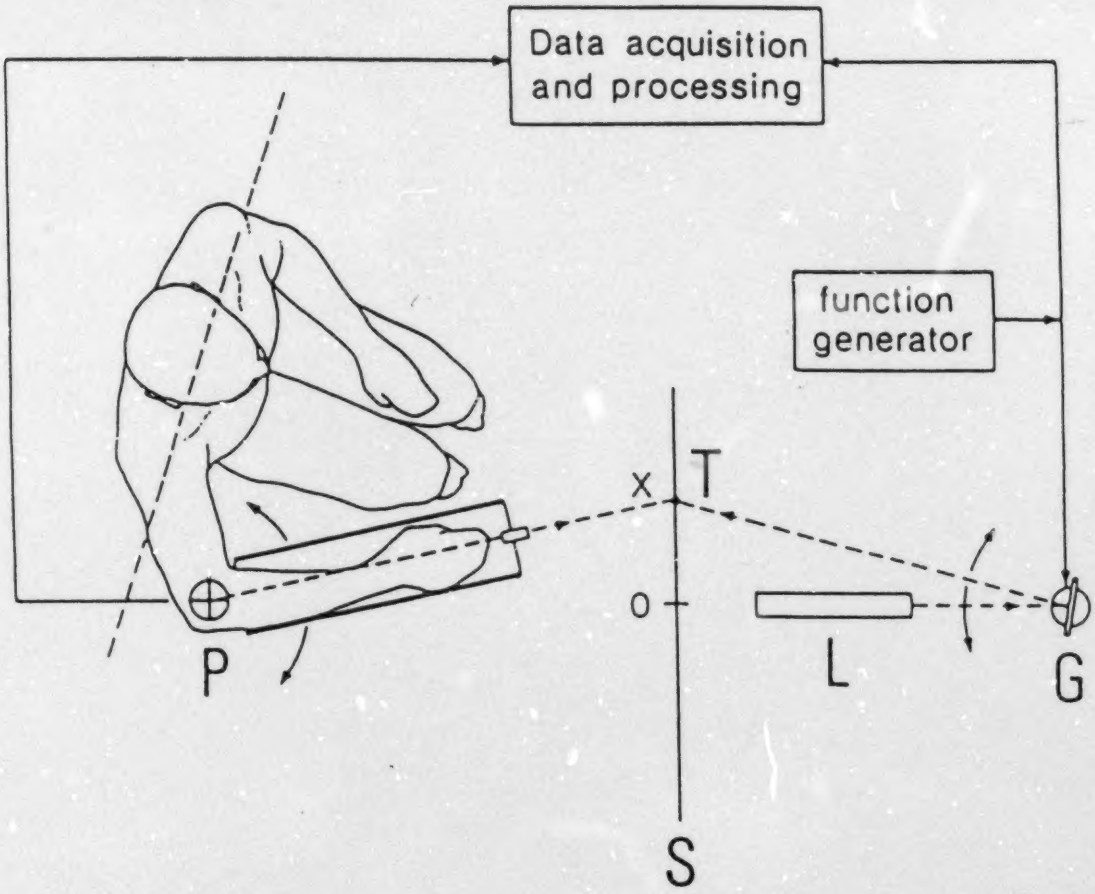


FIGURE 1 : A LIGHT SOURCE (L) AND A GALVANOMETRIC MIRROR (G) PROJECT ON A SCREEN (S) A TARGET SPOT (T). THE SUBJECT HAS TO TRACK ITS POSITION (X) BY ROTATING HIS FOREARM WHOSE DISPLACEMENTS ARE MEASURED BY A POTENTIOMETER (P). ANGULAR POSITIONS OF BOTH THE FOREARM AND THE MIRROR ARE RECORDED (CF. FIG. 2).

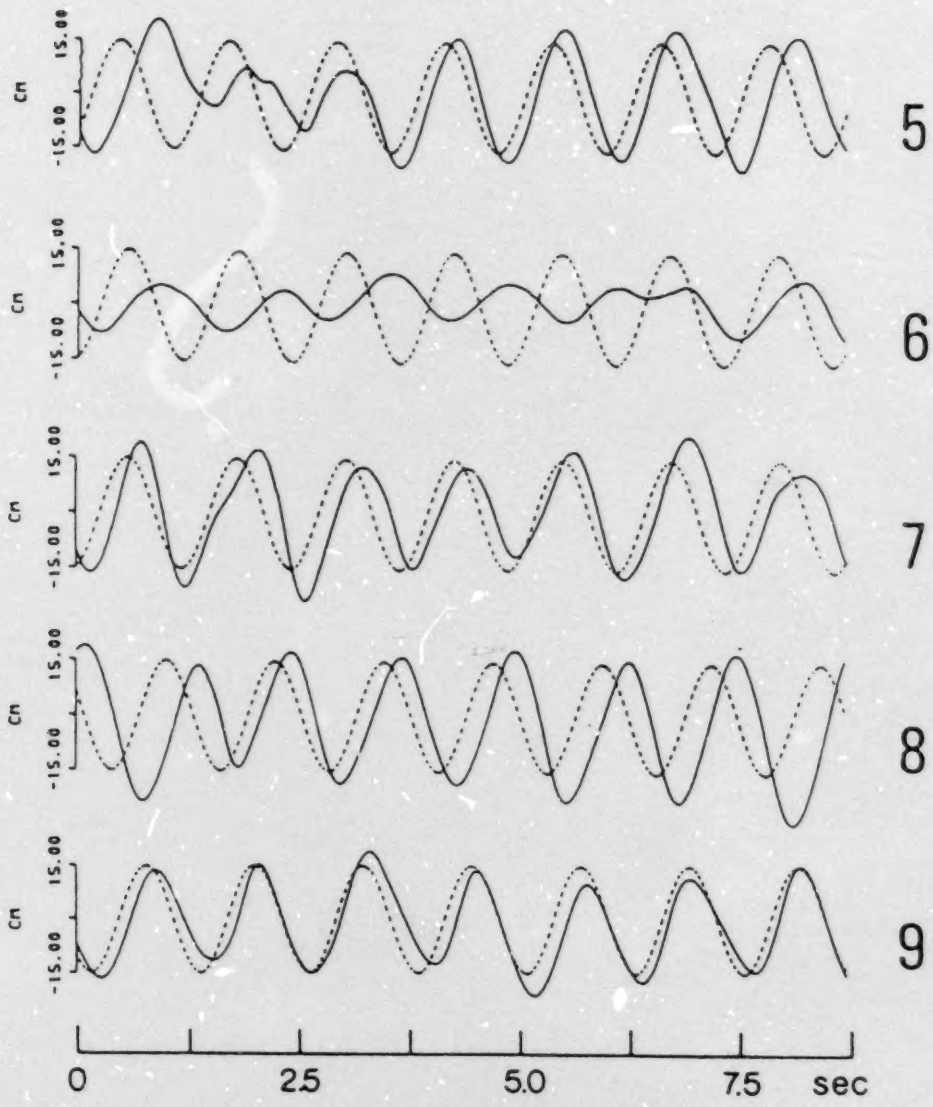
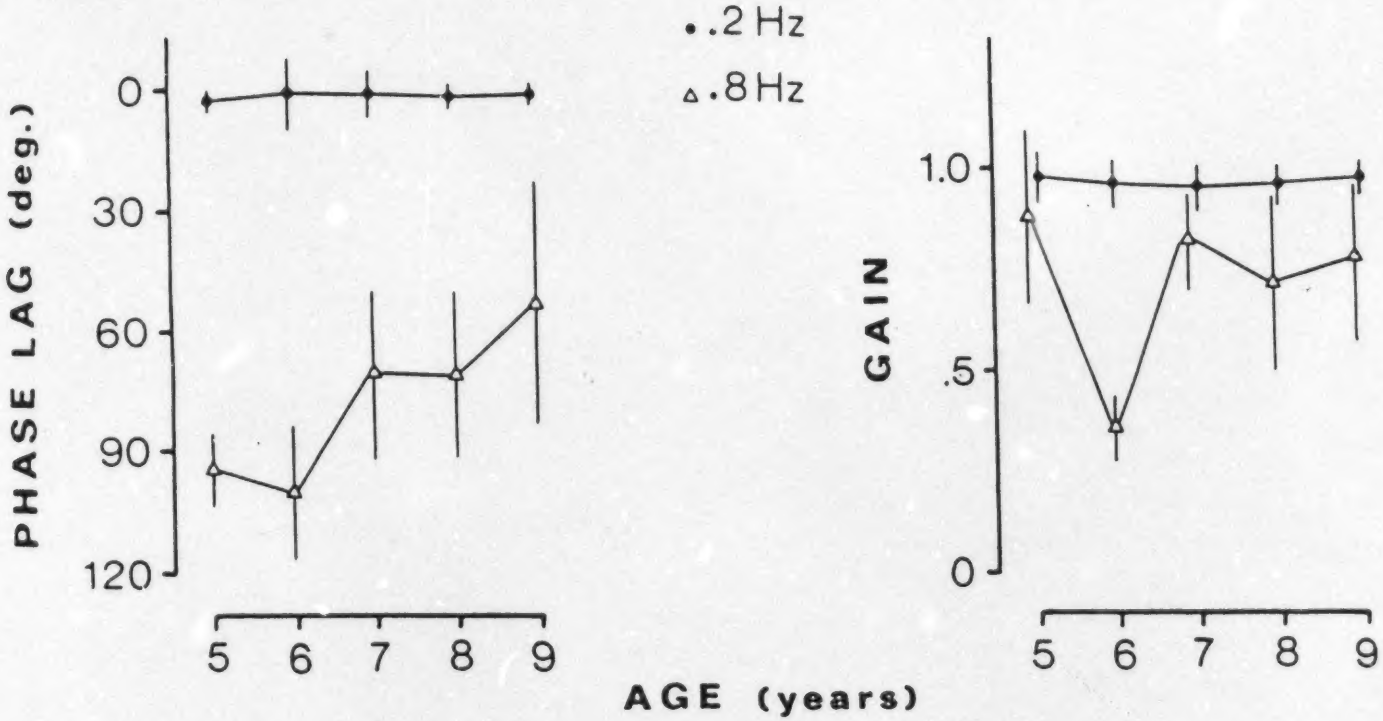


FIGURE 2 : EACH RECORD DESCRIBES 7 FULL CYCLES OF MOVEMENT OF TARGET (DASHED LINE) AND TRACKING (CONTINUOUS LINE) SPOT FOR A REPRESENTATIVE SUBJECT OF EACH AGE GROUP AT .8 HZ. DISPLACEMENTS ARE CALIBRATED IN CM ON THE SCREEN.



EIGURE_3 : THE LEFT GRAPH REPRESENTS THE PHASE DIFFERENCE BETWEEN THE STIMULUS AND THE HARMONIC COMPONENTS OF THE RESPONSE WITH THE SAME FREQUENCY OF THE TARGET. POSITIVE VALUES INDICATES THAT THE PURSUIT LAGS WITH RESPECT TO THE TARGET.
THE RIGHT GRAPH REPRESENTS THE RATIO BETWEEN THE AMPLITUDE OF THE RESPONSE AND THE AMPLITUDE OF THE TARGET.
EACH POINT IS THE AVERAGE OVER ALL SUBJECTS WHO COULD SUCCESSFULLY TRACK IN THE INDICATED AGE GROUP OF THE WITHIN-TRIAL MEAN VALUES.

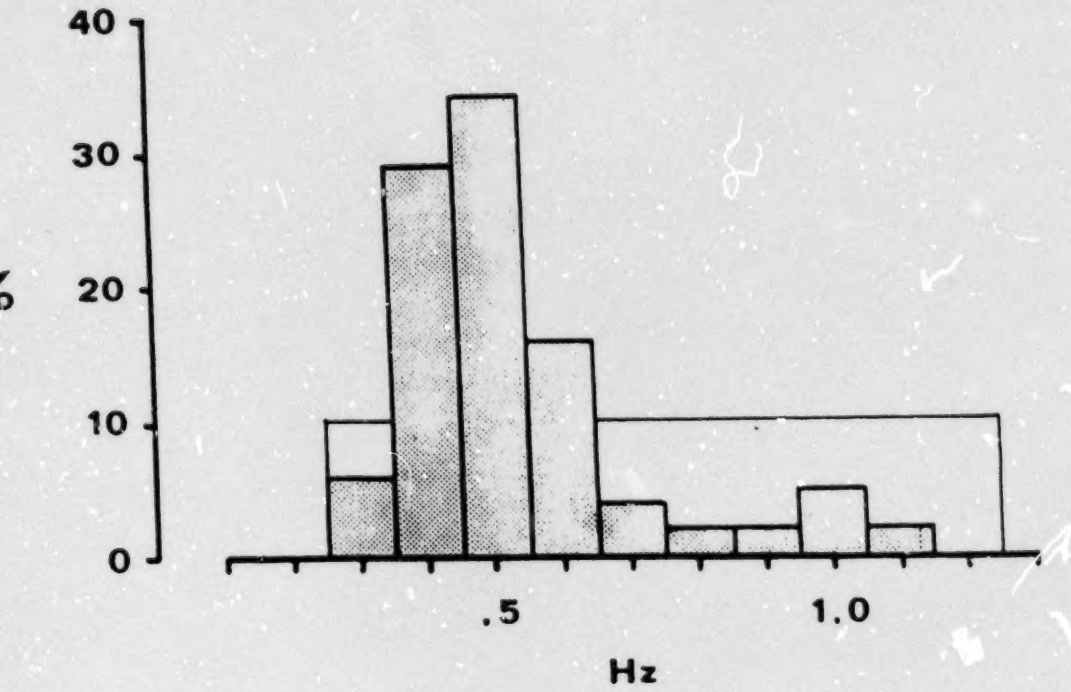
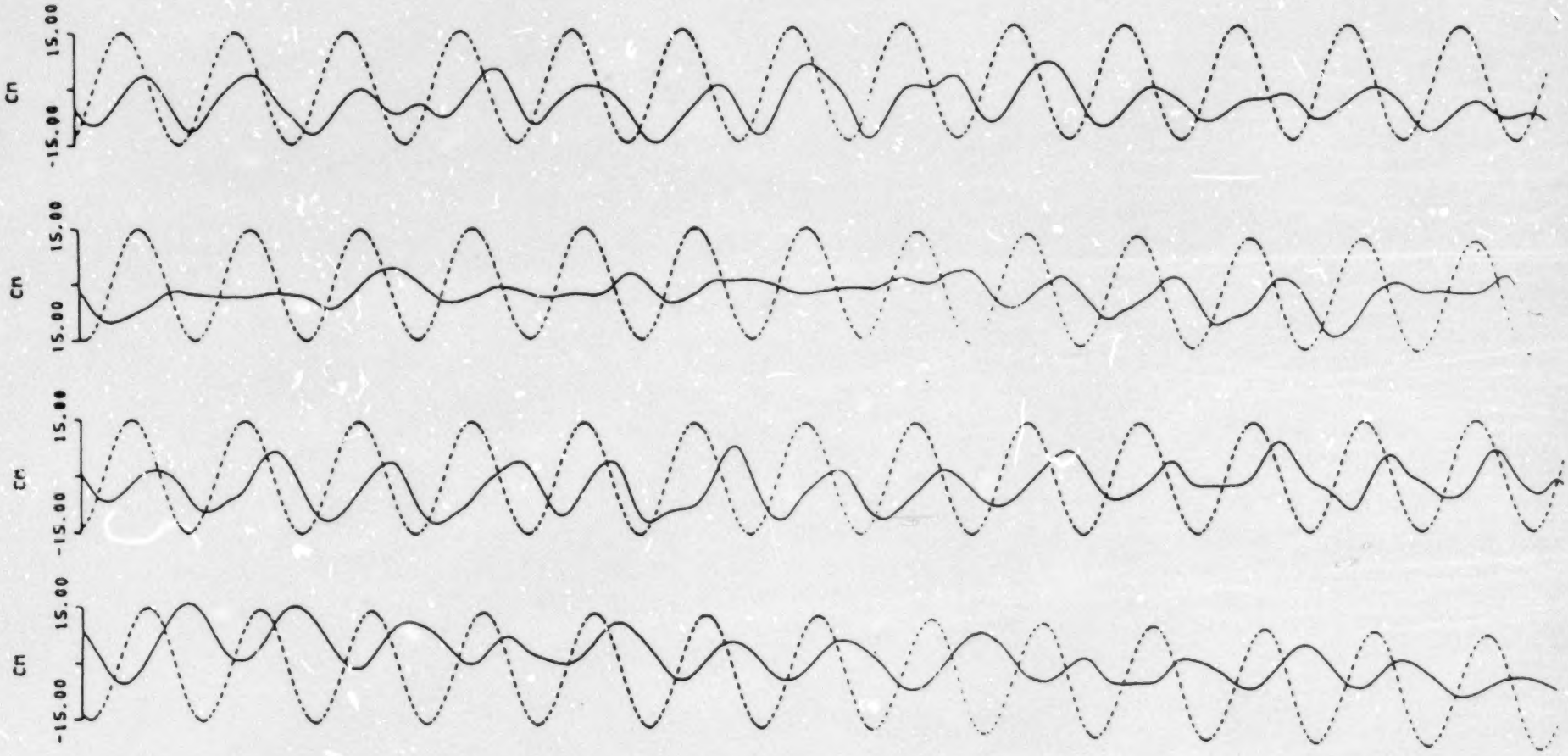


FIGURE 4 : HISTOGRAM OF THE FREQUENCIES OF MOVEMENTS PRODUCED BY THE 6 YEARS-OLDS (DARK AREA) IN RESPONSE TO A SINUSOIDAL AUDITORY STIMULUS VARYING FROM .3 TO 1.2 HZ (WHITE AREA).



EIGURE_5 : 4 TYPICAL EXAMPLES OF SUCCESSFUL TRACKING OF THE .8 HZ STIMULUS IN 6 YEAR-OLDS. DASHED LINE IS THE STIMULUS. CONTINUOUS LINE IS THE RESPONSE.

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